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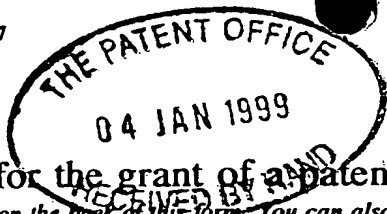
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1. Your reference	REP05986GB		
2. Patent application number (The Patent Office will fill in this part)	9900084.6		
3. Full name, address and postcode of the or of each applicant (underline all surnames)	<u>Microscience Ltd.</u> 67-68 Jermyn Street London SW1Y 6NY United Kingdom		
Patents ADP number (if you know it)			
If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom	7304546001	
4. Title of the invention	PROTEIN AND COMPOSITIONS CONTAINING IT		
5. Name of your agent (if you have one)	GILL JENNINGS & EVERY		
"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)	Broadgate House 7 Eldon Street London EC2M 7LH		
Patents ADP number (if you know it)	745002	✓	
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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing (day / month / year)	
8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if: a) any applicant named in part 3 is not an inventor b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body. See note (d))	YES		

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Continuation sheets of this form

Description 7

Claim(s) 1

Abstract

Drawing(s) 1 + 1

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Priority documents

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Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination (Patents Form 10/77)

Any other documents (please specify)

11. For the Applicant  
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature

Date

4 January 1999

12. Name and daytime telephone number of person to contact in the United Kingdom

PERRY, Robert Edward  
0171 377 1377

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## PROTEIN AND COMPOSITIONS CONTAINING IT

### Field of the Invention

This invention relates to one protein, to vaccines  
5 containing it, and to its use in therapy, for  
immunisation.

### Background to the Invention

Group B Streptococcus (GBS), also known as  
*Streptococcus agalactiae*, is the causative agent of  
10 various conditions. In particular, GBS causes:

*Early onset neonatal infection.*

This infection usually begins *in utero* and causes  
severe septicaemia and pneumonia in infants, which is  
lethal if untreated and even with treatment is associated  
15 with a 10-20% mortality rate.

*Late onset neonatal infection.*

This infection occurs in the period shortly after  
birth until about 3 months of age. It causes a  
septicaemia, which is complicated by meningitis in 90% of  
20 cases. Other focal infections also occur including  
osteomyelitis, septic arthritis, abscesses and  
endophthalmitis.

*Adult infections.*

These appear to be increasingly common and occur  
25 most commonly in women who have just delivered a baby,  
the elderly and the immunocompromised. They are  
characterised by septicaemia and focal infections  
including osteomyelitis, septic arthritis, abscesses and  
endophthalmitis.

30 *Urinary tract infections.*

GBS is a cause of urinary tract infections and in  
pregnancy accounts for about 10% of all infections.

### *Veterinary infections.*

GBS causes chronic mastitis in cows. This, in turn, leads to reduced milk production and is therefore of considerable economic importance.

5        GBS infections can be treated with antibiotics. However, immunisation is preferable. It is therefore desirable to develop an immunogen that could be used in a therapeutically-effective vaccine.

### Summary of the Invention

10        According to the present invention, a partial GBS gene sequence, pho3-17, has been found which represents a probable outer surface protein with unknown function.

         In one aspect of the invention, the use of this protein in a recombinant protein vaccine is described.  
15        This vaccine may be administered to females either prior to, or during pregnancy to protect mother and neonate against infection by GBS.

         The gene sequence may be first genetically altered to increase the antigenicity of the encoded protein.

### 20        Brief Description of the Drawings

         The invention will now be described in detail with reference to the accompanying figures, wherein:

         Figure 1 shows the nucleotide sequence of the insert of clone pho3-17 and the deduced amino acid sequence of  
25        ORF3-17.

### Description of the Invention

         Because of its extracellular or cell surface location, the protein of the present invention may be a suitable candidate for the production of therapeutically-effective vaccines against GBS.        The term  
30        "therapeutically-effective" is intended to include the prophylactic effect of the vaccines. For example, a recombinant protein may be used, as an antigen for direct administration to a patient. The protein may be isolated

directly from GBS expressed in any suitable expression system, e.g. *Lactococcus lactis*. It is preferably administered with an adjuvant, e.g. alum.

5 The protein may be a mutant protein, in comparison to wild-type protein, a fragment of the protein or a combination of different fragments, provided an effective immune response is generated.

10 An alternative approach is to use a live attenuated GBS vaccine. This may be produced by deleting the gene that encodes the protein. Preferably, the GBS strain comprises additional virulence gene mutations.

The protein (or fragments thereof) of the present invention may also be used to produce monoclonal and polyclonal antibodies for use in passive immunisation.

15 In a further embodiment of the invention, the protein or corresponding polynucleotide may be used as a target for screening potentially useful drugs, especially antimicrobials. Suitable drugs may be selected for their ability to bind to the protein to exert their effects.  
20 Assays for screening for suitable drugs and which make use of the protein of the invention will be apparent to those skilled in the art.

25 Although the protein has been described for use in the treatment of patients, veterinary uses of the protein are also considered to be within the scope of the present invention. In particular, the protein or the vaccines may be used in the treatment of chronic mastitis, especially in cows.

30 The present invention is described with reference to Group B Streptococcal strain M732. However, all the GBS strains and many other bacterial strains are likely to include related proteins having amino acid sequence homology with the protein of M732. Organisms likely to contain the proteins include, but are not limited to, *S.*

*pneumoniae*, *S. pyogenes*, *S. suis*, *S. milleri*, Group C and Group G *Streptococci* and *Enterococci*. Vaccines to each of these may be developed in the same way as described for GBS.

5        Preferably, the proteins that may be useful for the production of vaccines have greater than 40% sequence similarity with the protein of M732. More preferably, the proteins have greater than 60% sequence similarity. Most preferably, the proteins have greater than 80%  
10       sequence similarity.

      The protein of the present invention was identified as follows:

      A partial gene library of GBS (strain M732) chromosomal DNA was prepared using the plasmid vectors  
15       pFW-*phoA*1, pFW-*phoA*2 and pFW-*phoA*3 (Podbielski, A. et al. 1996. Gene 177:137-147). These plasmids possess a constitutive spectinomycin adenyltransferase antibiotic resistance marker, which confers a high level of spectinomycin resistance and is therefore easily  
20       selected. Furthermore, these vectors contain a truncated (leaderless) *Escherichia coli phoA* gene for alkaline phosphatase. The three vectors differ only with respect to the reading frame in which the leaderless *phoA* gene exists, as compared to an upstream in-frame *Bam*HI  
25       restriction enzyme site. Because this truncated *E. coli phoA* gene lacks the appropriate leader sequence for export of this enzyme across the bacterial membrane, extracellular alkaline phosphatase activity is absent when these plasmids are propagated in an *E. coli phoA*  
30       mutant (e.g. strain DH5 $\alpha$ ). The chromogenic alkaline phosphatase substrate, XP (5-Bromo-4-chloro-3-indolyl-phosphate), does not enter intact bacterial cells and therefore only exported or surface associated alkaline phosphatase activity can be detected. When exported or



surface associated alkaline phosphatase activity is present, the chromogenic XP substrate is cleaved to yield a blue pigment and the corresponding bacterial colonies can be identified by their blue colour.

5 Plasmid DNA was digested to completion with *Bam*HI and dephosphorylated using shrimp alkaline phosphatase. GBS genomic DNA was partially digested with *Sau*3AI, size fractionated on a sucrose gradient and fragments <1kb in size were ligated into the prepared pFW-*phoA* vectors. *E.*  
 10 *coli* strain DH5 $\alpha$  was chosen as the cloning host since it lacks a functional *phoA* gene. Recombinant plasmids were selected on Luria agar containing 100  $\mu$ g/ml of spectinomycin and 40  $\mu$ g/ml of the chromogenic XP substrate. *E. coli* transformants harbouring plasmids  
 15 containing GBS insert DNA that complements the export signal sequence of the leaderless *phoA* gene were identified by the blue colour of the colonies. Approximately 30000 different recombinant plasmids containing GBS insert DNA were screened in this manner  
 20 and 83 recombinant plasmids, which complemented the leaderless *phoA*, were chosen for further study.

From these experiments, one clone was selected containing a plasmid designated pho3-17. This plasmid contained a gene (or part thereof), which complemented  
 25 the leaderless *phoA*. Plasmid pho3-17 contained 375 bp of GBS DNA and the nucleotide and deduced amino acid sequences are shown in Figure 1.

A comparison of the amino acid sequence of ORF3-17 was performed and the results are shown in Table 1.

30 As shown in Table 1, homologues to the GBS ORF3-17 gene product can be identified in *Plasmodium ovale*, *Chlorella vulgaris*, *Enterococcus faecalis* and *Streptococcus pyogenes*. Limited similarity was shown between ORF3-17 and the plasmepsin enzyme from the

malaria parasite *P. ovale*. Plasmeprin is an outer surface aspartyl protease, which may play a role in virulence in this organism (Westling, J. et al. 1997. Exp. Parasitol. 87:185-193). Limited similarity was also  
5 shown between ORF3-17 and ORF63 from *C. vulgaris*. No known function exists for ORF63 from this organism. The *E. faecalis* and *S. pyogenes* homologues were identified from genome sequence data and no annotations were available as to the identity of the gene or gene  
10 products. However, these homologues were used to perform database searches and strong similarity is shown between these homologues and N-acetylmuramidase enzymes from a variety of bacteria. N-acetylmuramidase is an autolysin that is involved in cell division. Using this limited  
15 information along with the fact that ORF3-17 complemented the leaderless *phoA* gene, it can be concluded that the ORF3-17 product would most probably be located extracellularly.

Table 1. Database search results for ORF3-17 (57 amino acids)

Organism	Protein Accession	DNA Accession	Gene Name	% Similarity	% Identity	Alignment Length
<i>P. ovale</i>	TR:O611163	EM:AF001209	plasmepsin	35.09	29.82	57
<i>C. vulgaris</i>	TR:O20199	EM:AB001684	Orf63	45.28	28.30	53
<i>E. faecalis</i>	bp 1-636	Contig 6380 (rev)	Unknown	38.60	28.07	57
<i>S. pyogenes</i>	bp 8082-8648	Contig 226	Unknown	33.33	28.07	57

CLAIMS

1. A protein comprising an amino acid sequence encoded by the polynucleotide defined as ORF3-17 in Figure 1 or a homologue thereof with at least 60% sequence homology.
- 5 2. A protein according to claim 1, obtainable from the Group B streptococcal strain M732.
3. A protein according to claim 1 or claim 2, wherein ORF3-17 comprises the nucleotides 204-374.
4. A protein according to any of claims 1 to 3, for use  
10 in a method of therapy.
5. A polynucleotide which encodes a protein according to any preceding claim, its complement, or a fragment thereof.
6. The use of a bacterial protein according to any of claims 1 to 4, in the manufacture of a vaccine to treat  
15 bacterial infection.
7. The use according to claim 6, wherein the infection is a Group B streptococcal infection.
8. The use according to claim 6 or claim 7, wherein the infection is a focal infection.
- 20 9. The use according to claim 6 or claim 7, wherein the infection is a urinary tract infection.
10. Use of a product according to any of claims 1 to 5, for screening potential antimicrobial drugs.
11. An antimicrobial drug selected using the products as  
25 defined in claim 10.
12. A vaccine comprising a product according to any of claims 1 to 5.
13. A vaccine comprising a microorganism having a virulence gene deletion, wherein the gene codes for a  
30 protein according to any of claims 1 to 4.
14. An antibody raised against a protein according to any of claims 1 to 4.

Figure 1. Nucleotide and deduced amino acid  
sequence of clone pho3-17

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      10              30              50
GATCCTAGAGTAGTCAGTCAGTTGAAAAAGATAGCTCCACAATATGGTTT

      70              90
TGTCTTACGGTTTCCGGATGGTAAACAGCAGAAACAGGGGTAGGTTATG

     110             130             150
AAGATTGGCATTACCGCTATGTTGGGGTAGAGTCTGCAAAATATATGGTC

     170             190
AAACATCATTTAACATTAGAAGAATACATAACTTTATTAAAGGAGAATAA
START ORF3-17
|  210             230             250
CCAATGAGGAAACGTTTTTCCTTGCTAAATTTTATTGTTGTTACTTTTAT
M  R  K  R  F  S  L  L  N  F  I  V  V  T  F  I

     270             290
TTTCTTTTTCTTTATTCTTTTTCCGCTTTTAAACCATAAGGGAAAAGTAG
F  F  F  F  I  L  F  P  L  L  N  H  K  G  K  V  D

     310             330             350
ATGCTAATTCTAGGCAGAGTGTTACCTACACCAAAGAAGAATTTATACAA
A  N  S  R  Q  S  V  T  Y  T  K  E  E  F  I  Q

     370
AAAATTGTGCCAGATGCGCAAGATC 375
K  I  V  P  D  A  Q  D
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